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2024–2025 Florida Citrus Production Guide: Root Health Management[1]

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Developing and maintaining a healthy root system is important for establishment and long-term productivity of trees. Roots take up nutrients and water from the soil to transport them to the tree canopy (the leaves and fruit). The root system also acts as an anchor for the tree, which is important during high wind conditions, such as thunderstorms and tropical systems. At the same time, the leaves provide carbohydrates to grow and maintain a functional root system. In a healthy tree, the carbohydrate supply is balanced between new leaves, fruit, and roots. When root health is compromised, the root system has reduced nutrient and water uptake capacity, which can subsequently affect growth of new leaves and fruit.

Root health can be compromised by pests, pathogens, and environmental (abiotic) factors. Citrus root pests include Diaprepes root weevil, burrowing nematode, sting nematode, and others. Historically, the most damaging root pathogens in citrus have been *Phytophthora* spp. that cause root, crown, and foot rot. The most common detrimental environmental factors for roots in Florida citrus are soil pH, salinity, and flooding. An increase in soil pH above 7.0 results in precipitation of phosphorus, calcium, magnesium, and other plant nutrients, reducing the concentration of nutrients in solution available for uptake by the roots. A reduction of soil pH below 5.5 results in rapid leaching of nutrients such as calcium and magnesium from the soil and mobilization of toxic levels of micronutrients such as copper. Extended waterlogging (oxygen deprivation) and salinity can cause root decline and death. Site-specific decisions made while preparing to plant will reduce the risk and impact of these biotic and abiotic causes of root health decline. Management of root health problems depends on cultural practices and, when necessary, chemical management tools.

The root system has two main types of roots, structural and fibrous (feeder), which serve different essential functions for the tree. The structural roots provide the anchoring scaffold of the root system and act as the major transport corridors for nutrients, water, and carbohydrates. The fibrous roots form the interface with the soil where water and nutrients are absorbed, and they provide extra grip, or friction, to assist anchoring of the tree. Both kinds of roots are important for root and tree health and are affected differently by pests, pathogens, environmental factors, and any interactions of the three. Structural roots often extend outward to the edge of the wetted zone or canopy and then continue down and outward beyond the canopy. Fibrous roots only grow in high-density clusters from structural roots where water and nutrients are most abundant. In irrigated trees, the fibrous roots are concentrated in the wetted zone of the irrigation system. For example, microsprinkler irrigation concentrates 80% of the fibrous roots in the top 10 inches of the wetted zone under the canopy. Root systems are important to understand because root health

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management should be focused on these areas of high fibrous-root density.

Introduction of *Candidatus* Liberibacter asiaticus (*C*Las), the cause of huanglongbing (HLB), into Florida greatly complicates citrus root health management. *C*Las infection causes severe damage to fibrous roots, which exacerbates the effects of the other root pests and pathogens and can reduce the efficacy of treatments. Root health management has become more challenging and more important because most citrus trees in Florida are now affected by HLB.

Huanglongbing and Root Health

HLB severely affects root health, causing 30%–50% root loss early in disease development and greater than 70% root loss once canopy decline begins (sectored leaf drop and dieback). This root loss results from a shortened lifespan of 1.5–4 months for fibrous roots compared to 9–12 months for healthy roots. The shortened lifespan is accompanied by increased root growth, leading to an imbalance in carbohydrate demand in the tree and reducing the total uptake capacity of the root system. Structural roots also die back from HLB, with ~20% dieback within the wetted zone as canopy decline begins, continuing inward toward the trunk. Currently, there is no proven management option for prevention of HLB-associated root loss. Treatments that stimulate root growth are **not** recommended, because they may increase the root-canopy imbalance. Instead, growers should focus on altering soil applications to adapt to the limited uptake capacity and, when economically feasible, attempt to prevent further damage to the existing roots to maintain or improve root longevity. This includes irrigation and fertilization in small and frequent doses to balance the water and nutrient supply with uptake capacity and adjustment of soil pH between 6.5 and 5.8 to avoid additional stress on the root system.

Managing Root Health

A healthy root system improves productivity of trees and improves their tolerance of major stresses, such as freezes, drought, and high winds. Starting a grove with a healthy root system allows for rapid tree establishment and growth. Maintaining a healthy root system in existing groves lengthens the productive life of the trees.

Root Health in New Plantings

The best way to manage root health is to prevent problems from starting. This requires careful consideration and planning before ordering trees and planting a new grove. The largest contributors to root health that will affect pests, pathogens, and the tree itself are the soil and water at the site. The most cost-effective way to manage root health is proper field preparation for planting and choosing rootstocks based on site-specific knowledge of the soil and irrigation water. Flooding and water table problems that affect root health can be managed with land preparation, including drainage and bedding (see chapter 13, "Grove Planning and Establishment"). Many of the soil, pest, and pathogen problems can be addressed by choosing the best-adapted rootstock. To select a rootstock, you need to know the site history, such as existing nematode problems or previous infestations of Diaprepes. It may also be important to know what has been done in the past to modify soil pH. If recent efforts were made to change the soil pH with liming or sulfur, it is likely that the soil will slowly shift back to its native pH. To avoid the perennial expense of adjusting the pH in your grove, select a rootstock with an appropriate pH tolerance. Rootstock selection can be difficult because there is limited knowledge about soil preference and pest and pathogen resistance for some rootstocks (especially newly released rootstocks). To help in the selection process, a summary of what is known for commercially available rootstocks can be found in chapter 12, "Rootstock and Scion Selection", and the *Citrus Rootstock Selection Guide*. Some locations may have multiple pest, pathogen, and environmental problems. In these cases, a rootstock that addresses all the problems may not be available. It is important to consider which problems are the most severe at the site and which can be most easily and economically managed by land preparation or on a regular long-term basis. In situations where multiple problems cannot be addressed by proper rootstock selection, alternative crops should be investigated.

Starting with healthy root establishment is also important. When planting trees, it is important to give them the best chance to establish a healthy root system. This requires inspecting the root balls for signs of phytophthora damage, a pot-bound root system, or dry potting medium. Phytophthora damage will slow or prevent root establishment, immediately stunting trees. Dry potting media will inhibit water penetration after planting, leading to tree stunting or death. Pot-bound root systems can lead to intertwined structural roots that can cause tree stunting and decline a few years after planting as the structural roots begin to girdle each other. For more details, see chapter 13, "Grove Planning and Establishment".

Root Health for Existing Groves

Unlike new plantings, root health problems in existing groves have to be managed, not avoided. However, like new plantings, root health in existing groves requires site-specific management. The first step is to identify the problems present in the grove. Take soil samples for pH and nutrient analysis as well as phytophthora and nematode counts. Determine the pH, salinity, and bicarbonate content of irrigation water. Bicarbonates are leached from limestone in the aquifer and act as a buffer raising the pH of the water and irrigated soil. Groves should be scouted for the presence of Diaprepes root weevil, and if they are known to be a problem, see chapter 27, "Citrus Root Weevils". Once the root health problems are identified, develop a decision-making process to determine which problems are the most severe and should be managed first. For example, if *Phytophthora* spp. are at damaging levels on roots, but there are also problems with soil pH and Diaprepes, addressing soil pH or Diaprepes may effectively reduce phytophthora populations in a grove's soil because these factors interact with phytophthora to make it worse than it would otherwise be. Therefore, pH or Diaprepes should be treated first, and phytophthora counts should be reassessed to determine if chemical applications for *Phytophthora* spp. are still needed. HLB-induced root damage also interacts with *Phytophthora* spp. by increasing the exudation of sugars from roots. This sugar exudation attracts *Phytophthora* zoospores, increasing infection. HLB also reduces the efficacy of fungicides (phosphite, focetyl-Al, fluopicolide, and mefenoxam) for control of *Phytophthora* spp. Timing is essential to maintain efficacy of phytophthora management applications. Propagule counts should be monitored carefully for developing problems, so late summer or fall root flushes (root flushes follow leaf flushes) can be protected. For more information, see chapter 31, "Phytophthora Foot Rot, Crown Rot, and Root Rot".

Soil pH and bicarbonates in irrigation water have gained attention because HLB has reduced the tolerance for pH incompatibilities on rootstocks mismatched with grove soil, such as Swingle on high-pH soils. In many cases, especially in the flatwoods, management of pH and bicarbonates resulted in increased root density of trees with HLB. For reasons yet to be determined, groves on ridge soils do not respond as well to pH and bicarbonate management. Soil pH or high-bicarbonate irrigation water can be treated with ground-applied sulfur or by acidifying irrigation water with injections of sulfuric or N-phuric acid. For Swingle rootstock, the ideal pH range is 5.5 to 6.5. Recent field experiments have determined that maintaining soil pH in the 5.5 to 6.5 range increases nutrient uptake and root density. Test the pH before and after treatment, because overacidification could lead to the release of toxic amounts of copper and other metals and depletion of essential nutrients, such as calcium and magnesium, from the soil. Extra care needs to be taken to avoid overacidification when using sulfur. Sulfur acidification is dependent on the microbial breakdown of elemental sulfur and can take a year or more before soil pH drops. The soil pH is very likely to drop below the optimum range if other acidification methods are used before the sulfur takes effect.

Depending on the results of soil tests for nutrients such as calcium, supplemental application may be necessary to replenish those lost from leaching and to prevent copper toxicity to roots. When pH management is necessary, sources of calcium that do not counteract pH management should be chosen; for example, applying gypsum ($CaSO_4 \cdot 2H_2O$) instead of lime can add calcium without increasing the soil pH.

Managing Soil Health for Root Health

Cultural practices to manage the quality, or health, of soils may also improve root growth and health. One of the key components of healthy soils is soil organic matter, which in turn is critical for maintaining or increasing microbial diversity. There is increasing evidence that greater soil microbial diversity can improve root growth through reduction of disease incidence and influence on nutrient availability. While Florida citrus soils generally have low soil organic matter content, cultural practices such as planting cover crops can increase soil organic matter. Recent field trials have measured significant increases in soil organic matter and microbial diversity when cover crops are planted year-round in Florida citrus groves. Cover crops can be planted either only in the row middles or trunk to trunk. Because citrus roots extend into the row middles, benefits of cover crops may still apply even if they are only planted in the row middles. The increased biomass provided by cover crops contributes to soil organic matter through decomposition. Legume cover crops may also provide additional nitrogen. Together, these changes can enhance microbial abundance and activity and impact root growth.

Web Address for Link

"Citrus Rootstock Selection Guide": https://crec.ifas.ufl.edu/extension/citrus_rootstock/